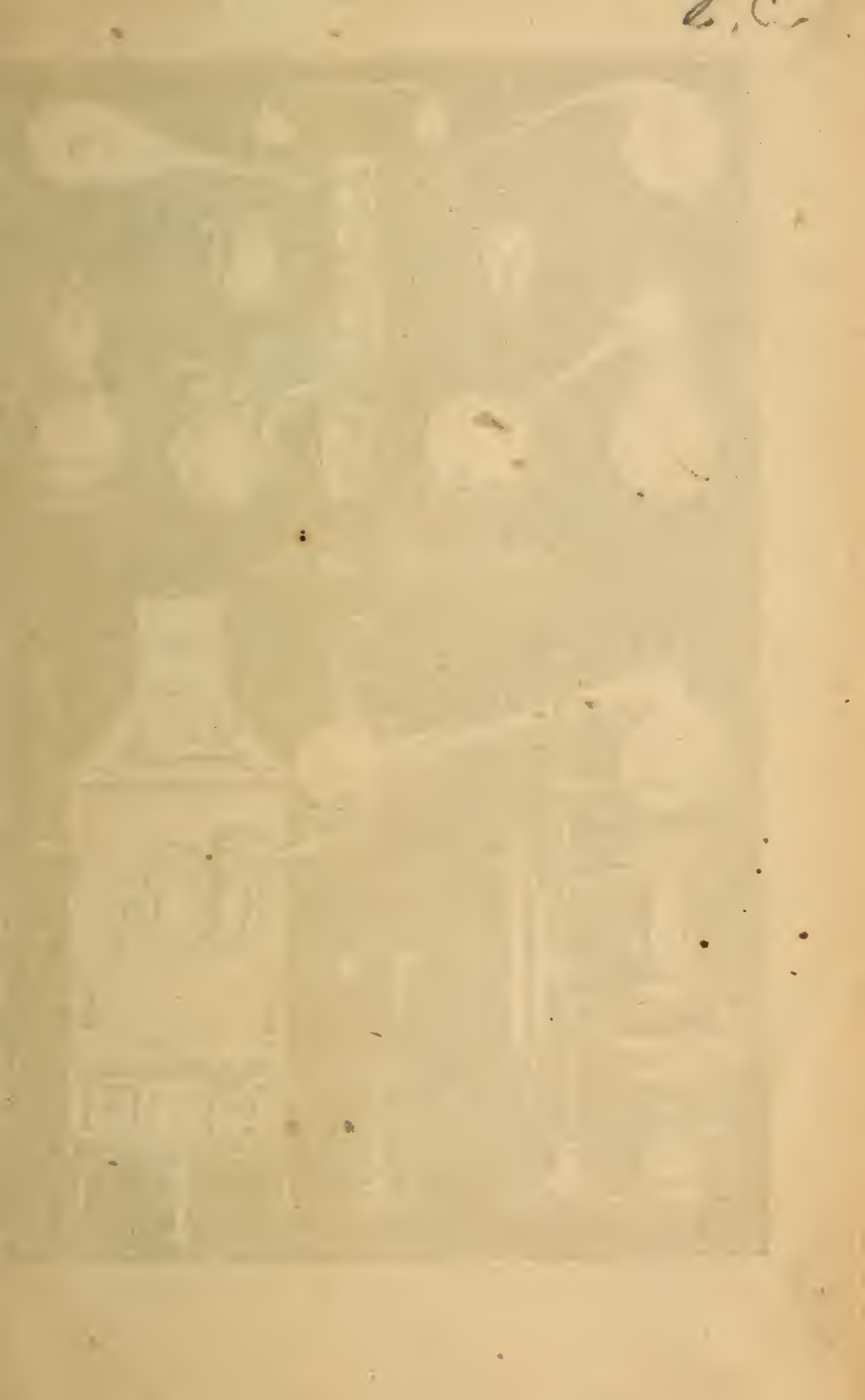

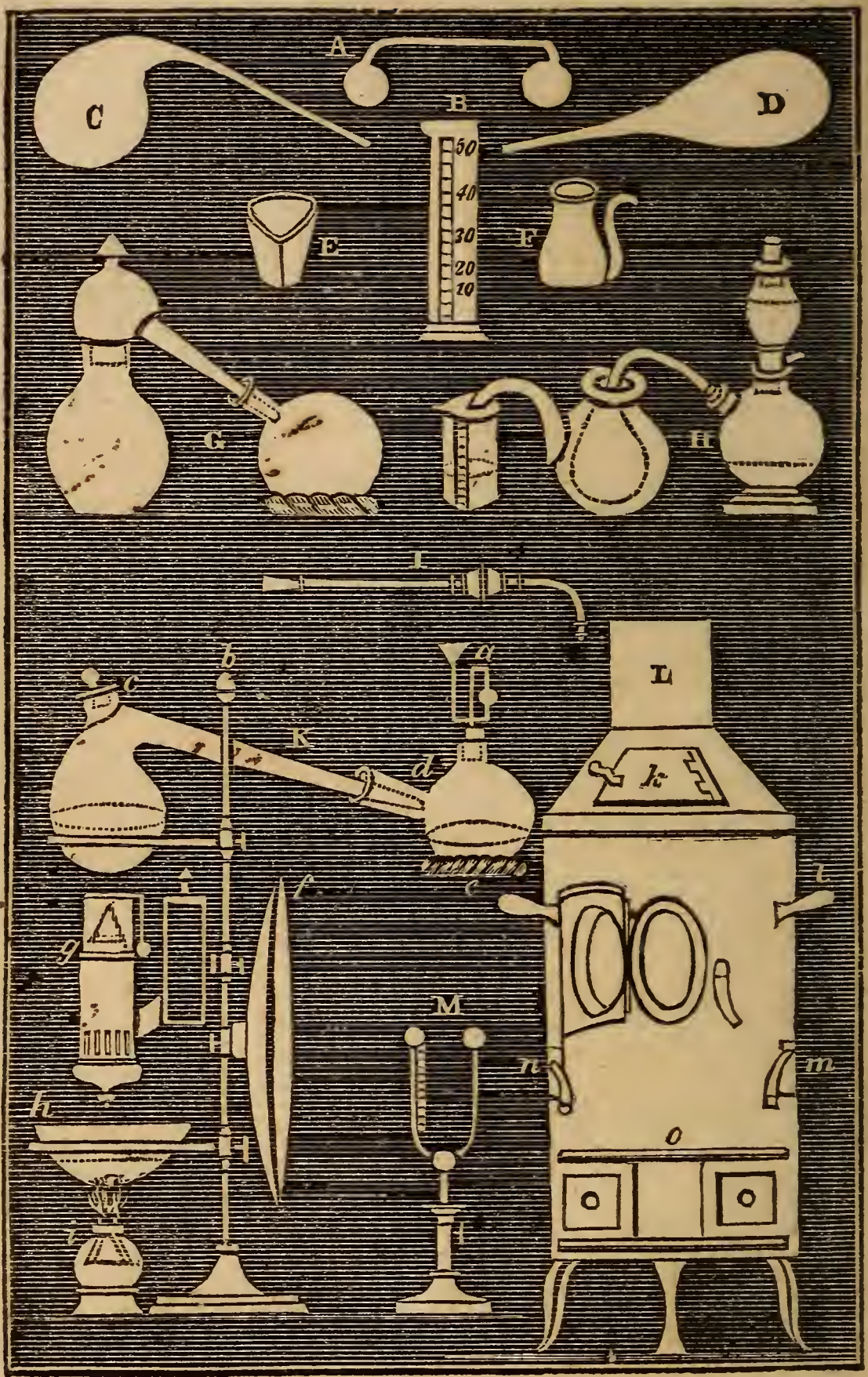
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IRVING'S

CATECHISM

OF

Practical Chemistry:

BEING A

FAMILIAR INTRODUCTION

TO THAT

INTERESTING SCIENCE.

WITH AN APPENDIX, CONTAINING MANY

Safe, Easy, and Pleasing Experiments.

WITH ENGRAVED ILLUSTRATIONS.

FIFTH AMERICAN EDITION, REVISED AND IMPROVED,

By M. J. KERNEY, A.M.

Author of Compendium of Ancient and Modern History, First Class Book of History, Catechism of the History of the United States, Columbian Arithmetic, &c. &c. &c.

Adapted to the Use of Schools in the United States.

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PREFACE.

The long established reputation of Irving's Catechisms precludes the necessity of adding any comments on their merits. The very extensive circulation which they have had, not only in England, but also in this country, is the best proof of their utility. The plan of his works is the very best that could be adopted. The catechetical form of instruction is now admitted, by the most experienced teachers, to be the best adapted to the nature and capacity of youth;—a system by which children will acquire a knowledge of a science in less time than by any other.

The present number, on Chemistry, will be found to possess peculiar merits. It lays open to the mind of the learner, all the most interesting and important portions of the science; and though, originally designed for the young, it will prove a valuable compendium, which the more advanced in years may read with pleasure and profit.

The present edition has been carefully revised, and corrected. It has been replenished with all the improvements, which modern discoveries have added to the science. The improvements, it is hoped, will add much to the merits of the work, and render it still more deserving of that liberal patronage which it has already received.

EXPLANATION OF THE PLATE.

A. Wollaston's Cryophorus.

B. Is a rain-guage correctly graduated; and is generally adapted to an evaporating apparatus.

C. A glass retort, which may be made of various sizes, according to the purpose for which they may be wanted.

D. A bolthead for digesting tinctures; for which purpose it is placed with the bulbous end in a sand bath.

E. A Crucible, which should be of different sizes for the convenience of different chemical experiments.

F. Is a vessel for separating oils and other fluids.

G. Is a glass alembic, and should be made to contain from half a pint to three quarts.

H. Is Davy's glass apparatus, for the analysis of earths, by the disengagement of gas.

I. Is Pepys's improved ball blow-pipe.

K. Is a complete apparatus for distillation: *a* is Welter's safety tube, to be adapted to retorts or receivers; *b* is a lamp-furnace with brass pillar and stand, sliding rings, and fountain-lamp; *c* shows the form of a retort, which may be made of glass, earthen-ware, or porcelain; *d* is a glass receiver for holding the products of distillation; *e* is a cushion, on which the last described apparatus is placed to prevent it from breaking; *f* is a metallic reflector for showing Pictet's experiments on radiant heat; *g* is a portable Argand's lamp for chemical purposes; *h* is a glass evaporating dish; *i* is a glass spirit-lamp.

L. Is a table furnace; *k* is a door in the cover, through which the fuel (charcoal) is to be introduced; *l* an opening which serves as a chimney when the top is taken off and a sand pot is to be used: or it will admit the neck of a retort, for the purpose of distilling with the naked fire; *m*, *n*, two apertures opposite to each other, through which an iron, earthen, or other tube might be passed, in order to demonstrate the decomposition of water, and for other operations which require a similar arrangement; *o* the door of the ash-pit.

M. A differential thermometer, which is attached to the metallic reflector.

CONTENTS.

APPENDIX.

SIMPLE AND AMUSING EXPERIMENTS.

A

Catechism of Chemistry.

CHAPTER I.

General Principles.

Q. What is Chemistry?

A. Chemistry is the science which teaches us how to ascertain the nature and properties of bodies, and to explain the intimate action of all natural substances on one another.

Q. By what means is this science principally acquired?

A. The methods, by which the knowledge of chemistry is acquired, are *analysis* and *synthesis*.

Q. What do you mean by analysis?

A. Analysis signifies the separation, or decomposition of the constituent parts of a compound substance.

Q. What is to be understood by the term synthesis?

A. By the term synthesis is meant the formation or composition of a compound body, by the artificial reunion of its constituent principles.

Q. What do you mean by decomposition?

A. By decomposition is meant the art of dividing a body into its simple elements.

Q. What kind of facts does chemistry contain?

A. Chemistry contains a detail of those facts which are founded on observation and experiment.

Q. Of what importance is the science of chemistry?

A. From its connection with the operations of nature and the existence of man, chemistry is of great interest, and highly worthy of accurate study.

Q. What are the advantages arising from this science?

A. Chemistry discovers the causes of many important phenomena; it enables us to reason concerning those properties of bodies which most immediately affect us, and to predict their alterations; and it develops sublime views of the order and harmony of the different parts of our system.

Q. What are the different states of natural bodies?

A. The different states of natural bodies may be divided into four classes; namely, solid, liquid, aeriform, and imponderable.

Q. What is meant by a solid body?

A. Solidity is that property in bodies by which their parts firmly cohere.

Q. What do you mean by liquid substances?

A. By liquid substances are meant those, the parts of which do not firmly cohere, but readily

yield to impression; and which also assume, when in small masses, a spherical form, being incapable of being compressed into a less compass by mechanical force.

Q. What do you call aeriform substances?

A. All elastic fluids, generally called vapors and gases, belong to the aeriform class.

Q. What are imponderable bodies?

A. They are only four in number, namely, light, caloric, electricity, and magnetism: they are also occasionally denominated etherial substances.

Q. Why is the air termed a fluid?

A. The air is called a fluid, because light substances float in it, and it flows like a liquid body.

Q. Why do some substances sink, and others swim in the same fluid?

A. Bodies which sink in a fluid are heavier than that fluid, and those which swim are lighter; as for instance, in water, a body heavier than the same bulk, must fall to the bottom.

Q. How do you express the relative weight of bodies?

A. The relative weight of bodies is called by the name of specific gravity.

Q. What is meant by specific gravity of bodies?

A. When any body is larger, and takes up more space than another of the same weight, the former, we say, is specifically lighter than the other, and the latter specifically heavier.

Q. How is the difference in the specific gravity of bodies denoted?

A. The specific gravity of bodies is denoted by

comparing it with the weight of pure water, in decimal figures, always considering water as 1·00. Thus the specific weight of iron is 7·65, or more than seven and a half times heavier than water; —that is, a cubic inch of iron would require more than seven and a half inches of water to balance it.

CHAPTER II.

Atmospheric Air.

Q. WHAT do you observe of atmospheric air?

A. Our atmosphere is not, as was formerly supposed, a simple fluid, but in reality composed of two distinct substances, termed oxygen gas and nitrogen gas, in the proportion of 20 of the former and 80 of the latter.

Q. Is the atmosphere composed of nothing more than oxygen and nitrogen?

A. Besides the above-mentioned bodies, the atmosphere contains a small portion of another gaseous fluid, termed *carbonic acid;* also a large portion of water, and a variety of substances which are subject to evaporation.

Q. What are the characteristic properties of atmospheric air?

A. The characteristic properties of atmospheric air are gravity, elasticity, dilatability, and fluidity.

Q. What is meant by the elasticity of the air?

A. By the elasticity of atmospheric air, we mean, that when compressed, it will recover its former shape, when the pressure is removed.

Q. What do you mean by the dilatability of the atmosphere?

A. The dilatability of the air is the capacity of being rarified, so that with increased heat it requires an increased space.

Q. What is the extent of the atmosphere?

A. The atmosphere ascends 45 miles above the earth, but as the height increases it becomes gradually attenuated.

Q. What is the weight of the atmosphere?

A. A column of air of the height of the atmosphere, one foot square, weighs about 2160 pounds, or about 15 pounds on every square inch.

Q. What are the advantages of the atmosphere?

A. For the support of both animal and vegetable life, atmospheric air is indispensably necessary; it is also requisite in combustion; it conveys sound, and those minute particles of odorous bodies which excite smell; and it enables birds to move with ease and quickness.

Q. Are there any other advantages arising from the atmosphere?

A. Without atmospheric air there would be no cold water, for the waters would evaporate at a low temperature; and the arteries of all animals, with the corresponding vessels in plants, would become too distended for the continuance of life.

Q. How is water secured to us by means of atmospheric air?

A. The pressure of the atmosphere upon the water confines it down, and prevents the heat of the sun from turning it into vapor.

Q. What is meant by gas?

A. Gas is a substance rendered aeriform by heat; and so termed to distinguish it from those aeriform substances which, when no longer under the influence of heat, return to a solid or fluid state.

Q. What are the properties of oxygen gas?

A. Oxygen gas supports combustion, heat, and life.

Q. What have you to observe of the properties of nitrogen gas?

A. The qualities of nitrogen are generally opposite to those of oxygen: it will not support combustion; it will immediately destroy life and extinguish light; it will not burn, and is lighter than atmospheric air.

Q. What is meant by caloric?

A. The name given by chemists to fire or heat, is caloric; and a large portion is combined with atmospheric air.

Q. How do clothes retain the heat of the body?

A. In this climate the temperature of the atmosphere is inferior to that of the body; consequently, clothes are necessary to prevent the heat of the body, which has been separated from the air by the lungs, from suddenly escaping.

CHAPTER III.

Of Caloric.

Q. WHAT have you to say on the subject of heat?

A. We acquire the sensation of heat from substances that are warmer than our bodies.

Q. What term has been given by philosophers to heat?

A. To prevent perplexity and confusion, in philosophical discussions, it was determined to adopt the word *caloric*, denoting that quality or principle which produces the sensation of heat, as distinguished from the sensation itself.

Q. Of what use is caloric?

A Caloric is indispensable to human life; by fire food is prepared, metals are dissolved, and the necessary forms and combinations given to all productions.

Q. How is caloric produced?

A. Caloric is produced by six different methods, namely: from combustion, by the sun's rays, by friction, by percussion, by the mixture of substances, and by electricity and galvanism.

Q What is the principal source of caloric?

A. The sun, the principal, and it is probable, the only original source of caloric, supplies the earth, and enables it to support vegetable and animal nature.

Q. In what manner does combustion furnish caloric?

A. A *decomposition* of the oxygen gas of the atmosphere takes place by combustion; and caloric, one of its component parts, obtains freedom.

Q. How does percussion produce caloric?

A. Percussion produces heat by the *compression* of the particles of the body; and by that means, forces out a portion of its latent caloric.

Q. How does friction produce caloric?

A. It has not been accounted for how friction produces caloric, unless we suppose it to be a succession of percussions.

Q. Do electricity and galvanism produce great heat?

A. Yes, by means of the electrical battery, or of the galvanic apparatus, a very great degree of heat may be produced.

T. Describe the production of heat by means of mixture.

P. When caloric is produced by the mixture of substances, the cause is to be attributed to the fluid part taking a more solid form.

Q. Are there any distinctions in caloric?

A. In all bodies there exists two very distinct portions of caloric.

Q. What are their peculiar distinctions?

A. One is termed *sensible* heat, or free caloric; and the other *latent*, or combined caloric.

Q. What is meant by free caloric?

A. Free or sensible caloric is a portion of heat disengaged from other bodies.

CHAPTER IV.

Specific and Latent Caloric.

Q. WHAT do you mean by latent caloric?

A. By latent caloric is meant that portion of heat which occasions no sensible addition of temperature.

Q. Have all bodies the same capacity for caloric?

A. Different bodies have very different capacities for caloric; but the same bodies have uniformly, except they undergo a change, the same capacity.

T. Give an example of this kind of change.

P. When gaseous substances become liquid, or those which are liquid become solid, their capacity for caloric is, in a great degree, lost; when solid bodies become liquid or gaseous, their capacity for caloric is increased.

Q. In all substances is the same quality of latent caloric to be found?

A. No; with different substances, caloric combines in very different proportions; and thus we say that one body has a greater capacity for caloric than another.

Q. What do you mean by specific caloric?

A. Specific caloric is that portion of caloric which is necessary to raise a body to any given temperature.

Q. By what instrument is the temperature of bodies generally measured?

A. The instrument used for measuring the temperature of bodies is called the Thermometer.

T. Describe the thermometer

P. The thermometer consists of a glass tube, containing a small quantity of mercury, with a small graduated plate attached to it: to preserve the metal from the pressure of atmospheric air, the tube is sealed.

Q. In what manner is the thermometer affected by the different temperatures?

A. The mercury is expanded by heat and rises in the tube, and is contracted by cold and descends; hence by the height at which the mercury stands in the tube, we are informed of the temperature.

Q. What do you observe of the effects of caloric?

A. Caloric increases the bulk of the substances with which it unites, and renders them specifically lighter than they were before. In some cases it promotes the union of substances, and in others, serves to separate bodies when united. It is also capable of converting all solid bodies into fluids.

Q. Have bodies, in general, a great chemical affinity for caloric?

A. The affinity for caloric is one of the weakest, as appears from the ease with which warm bodies part with their caloric to those of lower temperature.

Q. Is this fact universal?

A. It is a law of nature, that heated bodies communicate a portion of their free caloric.

T. Describe this law of nature.

P. If the temperature of the air be reduced below 32°, water imparts gradually its superabundant caloric, until being deprived of that amount which is necessary to retain it in fluidity, it is converted into ice.

CHAPTER V.

Of Water.

Q. WHAT is the composition of water?

A. Water consists of hydrogen and oxygen.

Q. Of what proportion of hydrogen and oxygen is water composed?

A. Water is composed of two parts of hydrogen, and one of oxygen, by volume; and one of hydrogen and eight of oxygen by weight.

Q. What are the different states in which we find water?

A. Water is found in four states, viz: solid or ice; liquid, to which the term water is commonly applied; vapor or steam; and united with other substances.

Q. What do you consider the most simple state of water?

A. The simplest state of water is ice, for in that it has least caloric.

Q. What is vapor, and what are its chief properties?

A. Vapor is essentially water; but, owing to the considerable quantity of caloric with which it is united, it takes the form of gas; vapor can support enormous weights; and is useful in raising minerals, even water, from great depths.

Q. At what degree of temperature will water freeze?

A. At 32 degrees of temperature.

Q. At what temperature will it boil?

A. At the temperature of 212 degrees.

Q. What is the weight of a cubic foot of water?

A. About 1000 avoirdupois ounces.

Q. By what means do you know that water is a compound substance?

A. Water has been decomposed by various means, and the proportion of its different parts accurately ascertained.

Q. By what particular means is water decomposed?

A. Water may be decomposed by means of electricity and galvanism, and by all living vegetables.

Q. What general account can you then give of oxygen?

A. Oxygen is a constituent part of water, and of air; and in the latter it is that element to which it owes the power of maintaining combustion and life.

Q. What further have you to observe of hydrogen?

A. Hydrogen, besides its constituting a part of water, has the property of burning with vital air; and when in the state of gas, is the lightest of all ponderable things.

Q. Do you observe any thing else peculiar to hydrogen gas?

A. From the great lightness of hydrogen gas, it has been used for the inflation of air balloons, which enables persons to traverse the clouds, and

forms one of the most curious, if not the most useful examples of science applied to the arts.

Q. How many times lighter is hydrogen than atmospheric air?

A. About 14 times lighter.

Q. What is the specific gravity of water?

A. A wine pint measure of water weighs about 1 pound. It is 825 times heavier than atmospheric air.

Q. What are the chief advantages derived from water?

A. Water is an essential constituent in the organization of all living bodies; and, as it is continually expended during the process of life, that waste must be also continually supplied; this supply being of absolute necessity, it is not left to chance, or even reason, but forms the object of imperious appetite.

CHAPTER VI.

Of Earths.

Q. WHAT are Earths?

A. Earths are such substances as are not ductile, are mostly indissoluble in water or oil, and preserve their constitution in a strong heat.

Q. What are the different earths?

A. The earths are nine, namely, silex, alumina, glucina, zirconia, yttria, magnesia, barytes, stron-

tites, and lime: the last four are termed alkaline earths; the others, metallic.

Q. What are the properties peculiar to earths?

A. Earths are all dry, insipid, and incombustible bodies, and have little or no taste.

Q. What is Silex?

A. Silex, *silica* or *siliceous earth*, is the principal constituent of a very great number of the compound earths and stones, forming the immense mass of the solid nucleus of the globe. Its specific gravity is 2·65, or more than two and a half times heavier than water.

Q. In what is silex found?

A. Silex is the basis of almost all the scintillating stones; such as flint, rock, crystal, quartz, agate, calcedony, jasper, &c.

Q. What have you to observe of silex in its pure state?

A. Silex when perfectly pure, exists in the form of a white powder, which is insipid and inodorous; it cuts glass, and scratches or wears away metals.

Q. What are the chief uses of silex?

A. Silex, in the state of gravel, is used, from its durability, for the formation of roads, in the composition of earthen-ware, porcelain, cements, glass, and every description of vitreous articles.

Q. How does silex form glass?

A. When in a state of extreme division, silex is soluble in alkalies; and when fused with them forms glass.

Q. How is silex obtained?

A. Silex may be obtained pure from flints, by

exposing them in a crucible to a red heat, and immediately plunging them into cold water, by which means they become brittle and are easily reduced to a powder.

Q. What is Alumina?

A. Alumina, or pure clay, is a kind of earth which derives its name from a salt called alum.

Q. What are the properties of alumina?

A. Alumina is white, soft, and insipid, adheres to the tongue, and causes a sense of dryness in the mouth; and when moistened with water, forms a tenacious, ductile kind of paste. Its specific gravity is 2.

Q. What are the uses of alumina?

A. Aluminous earth is used both by the dyer and calico-printer, in combination with acetic acid, fixing red and other colors upon calico.

Q. Is alumina of no other use?

A. Alumina is also used in potteries, from its tenacity, aptitude for moulding, and hardening in the fire, for making earthen-ware, porcelain, &c.

Q. What have you to observe of stone-ware?

A. Stone-ware is principally composed of alumina and silica; but a small portion of old pottery is generally introduced into its composition.

Q. What is the difference between this and common earthen-ware?

A. The difference between stone-ware and earthen-ware consists in burning and glazing; stone-ware suffering a greater degree of heat, and being glazed with muriate of soda (common salt) instead of oxide of lead.

Q. What is Glucina?

A. Glucina is an earth which was discovered in the diamond of Peru, and is composed of silex, argil, lime, and oxide of iron.

Q. What are the properties of glucina?

A. Glucina is white, light, and soft to the touch, insipid, adheres to the tongue, and is fusible by fire.

Q. What are the uses of glucina?

A. It is not yet known to what purposes glucina may by applied; but from the sweetness of its taste, we believe that nature, which forms nothing without its uses, has endowed this earth with properties which will prove at some future time of great importance to animal economy.

Q. What is Zirconia?

A. Zirconia is an earth which was discovered in a kind of hyacinth, in the Island of Ceylon; but the stone from which it is obtained has been since obtained in France, Spain, and other parts of Europe.

Q. What are the properties of zirconia?

A. Zirconia has a white color, is exceedingly heavy, and rough to the the touch, like silex; has neither taste nor odor, and is insoluble in water; but forms with it like a jelly.

Q. Where is Yttria obtained?

A. This earth was found in a fossil, at Ytterby, near Roslagen, in Sweden.

Q. How is it distinguished?

A. When separated from the fossil, where it is found, yttria is in the form of a fine, white, insipid

power, resembling glucina; but with this difference, that it is not soluble in fixed alkalies.

Q. What do you observe of Magnesia?

A. Magnesia is a very soft, white, light earth, with little taste or smell, and is insoluble in water: it is not found pure in nature, but is obtained by decomposition.

Q. What are the uses of magnesia?

A. Pure as well as sulphate and carbonate of magnesia, are used much in medicine; the two latter as purgatives, and the former as a most effectual antidote against mineral poisons.

Q. How is magnesia obtained?

A. Magnesia is usually produced by precipitating it from sulphate of magnesia by means of an alkali.

Q. What is Barytes?

A. Barytes is an earth generally known by the name of *terra ponderosa*, or ponderous earth: it is chiefly found in England.

Q. What are the properties of Barytes?

A. When pure, barytes is of a grayish white color, and, like alkalies, changes vegetable blues to a green, is very pungent and caustic to the taste, and has the property of uniting oil with water.

Q. What are its uses?

A. Barytes forms the most useful chemical tests, whether in a pure state, dissolved in water, or combined with acids.

Q. What do you observe of Strontites?

A. Strontites was discovered in a mineral brought

from a lead-mine of Strontian, in Argyleshire: the mineral is a carbonate of strontites, and has been found in very small quantities, in other countries.

Q. What properties does strontites possess?

A. When separated from its acid, strontites is considered to be a pure earth; and like barytes, soluble in water, of a grayish white color; taste acrid and alkaline, but not poisonous.

Q. What do you observe of the uses of strontites?

A. Strontites has not hitherto been employed for any useful purpose.

Q. What is Lime?

A. Lime, or calcareous earths, is a substance obtained by decomposing calcareous matters by the action of fire, which deprives them of their acid.

Q. What are the properties of lime?

A. Lime is of a white color, and of a very hot caustic taste; with the assistance of acids, it forms peculiar salts, which is the best proof of the identity of this, or any other earth.

Q. In what state is lime found?

A. In nature lime is never found pure, but always in a state of combination; commonly with an acid; but most frequently of all with carbonic acid, as in marble, limestone, chalk, &c.

Q. What have you to observe of the uses of lime?

A. Lime, when combined with acids, may be applied to various useful purposes; when in its pure state, it is used for mortar in building houses;

by farmers for manure, tanners, soap-boilers, sugar manufacturers, and others; also in medicine.

Q. Describe the uses of lime in soap manufactories?

A. With alkali, lime is mixed, in order to deprive it of carbonic acid, rendering it what is called *caustic,* and by this means enabling it to combine with oil, which is converted into soap.

CHAPTER VII.

Of Alkalies.

Q. WHAT is an Alkali?

A. An Alkali is a substance of an acrid taste, and has the property of changing the blue juices of vegetables to a green, and the yellow to a brown; and of causing oils to mix with water.

Q. What other peculiar properties do you observe of the alkalies?

A. Alkalies are incombustible, soluble in water, form various salts by being combined with acids, and act as very powerful caustics, when applied to the flesh of animals.

Q. What number of alkalies are there?

A. There are three; two of which have been termed *fixed* alkalies, the other *volatile* alkali.

Q. What are the fixed alkalies?

A. Potash and Soda.

Q. Why are they termed *fixed* alkalies?

A. Potash and soda are called fixed alkalies, because they endure great heat without being volatilized; at a high temperature, however, they dissipate in vapor.

Q. Of what are these alkalies composed?

A. Until very recently, the fixed alkalies were considered simple substances, no one having succeeded in decomposing them; but it is now ascertained that they are compounds.

Q. What historical account is given of the discovery of these bodies?

A. The Gauls and Germans of antiquity were acquainted with potash; and the Greeks and Jews with soda, which had, with them, the name of nitre.

Q. How is potash obtained?

A. If any vegetable substance be burned in the open air, and the ashes repeatedly washed with water, till it passes tasteless, and if this liquid be evaporated to dryness, the substance which remains is *potash.*

Q. How is soda procured?

A. Soda, like potash, is obtained by lixiviation from the ashes of burnt plants; but only from those which grow upon the sea-shores; the variety of which, employed for this purpose, is very considerable.

Q. Is soda obtained by any other means?

A. Soda, combined with carbonic acid, is found in great abundance in the natron beds of Egypt, and in the East Indies.

Q. By what particular properties are these two alkalies distinguished?

A. Most qualities in the fixed alkalies are very similar; but they may be distinguished from the different salts which they form, when in combinations with acids, soda being not so deliquescent as potash.

Q. What have you to observe of the uses of these alkalies?

A. Fixed alkalies, which are the bases of different salts, are of considerable service in medicine and surgery, and in the arts in general.

Q. In what manner are alkalies employed in the arts?

A. Alkalies are used by dyers, soap-boilers, glass-blowers, color-makers, and other manufacturers.

Q. Why are fixed alkalies used in forming colors?

A. Without fixed alkalies many colors in this country could not possibly be manufactured; as Prussian blue, Potter's blue, and French and mineral greens.

Q. What other benefits are derived from those alkalies?

A. The alkalies are used in making alum, bleaching linen, scouring wool, and many other necessary processes, too numerous to mention.

Q. By what means are alkalies purified for the use of the chemist?

A. Soda or potash having had quick-lime applied to free it from carbonic acid, is lixiviated in fit vessels, that a solution may be obtained without any mixture.

Q. Are fixed alkalies ever used when combined with carbonic acid?

A. Potash and soda receive from carbonic acid the property of crystallizing readily, which also makes them mild and applicable to processes in which caustic alkali would be highly improper; thus, carbonate of potash is used medicinally, and carbonate of soda for the purpose of washing, &c.

Q. What chemical name is given to the *volatile alkali?*

A. The volatile alkali is termed ammonia.

Q. What do you observe of the properties of ammonia?

A. When combined with water, or any other body, ammonia exists in a gaseous state, and is so extremely volatile, that it exhales at all known temperatures. It is lighter than atmospheric air in the proportion of 6 to 10.

Q. Being a gaseous substance, how can it be employed in the arts?

A. Ammonia having an affinity for water, readily combines with it, and forms *liquid ammonia;* in which condition it is commonly used.

Q. Of what is ammonia composed?

A. Ammonia is composed of nitrogen and hydrogen, in the proportion by weight of four parts of the former with one of the latter; and by measure three of hydrogen and one of nitrogen.

Q. Is ammonia capable of decomposition?

A. This alkali may be decomposed by electricity; also by oxygen gas, with the assistance of heat; in which case nitrous acid and water will be the result.

Q. By what means is ammonia procured?

A. Ammonia may be procured by mixing equal quantities of muriate of ammonia and lime, separately reduced to powder; when put into a retort, the heat of a lamp should be applied, and the gas received; also all animal and vegetable substances, when in a state of putrefaction, will yield ammonia.

Q. Are there no other means to procure this alkali?

A. Ammonia is generally procured in this country by a dry distillation of animal substances, such as bones and horns.

Q. For what purpose is ammonia used?

A. The liquid ammonia is used for various purposes in manufactories, in medicine, and is a very valuable re-agent to the chemist; and when in combination with carbonic acid, it takes a concrete form of a beautiful white color, and is sold in the shops under the name of *volatile salts.*

Q. By what process does ammonia form muriate of ammonia?

A. By combining muriatic acid with ammonia, muriate of ammonia is formed; it is commonly termed *sal-ammoniac.*

Q. What are the uses of sal-ammoniac?

A. It is used in medicine and many manufactories; especially by dyers, to impart a brightness to certain colors; by braziers too, tinplate-workers, and others.

CHAPTER VIII.

Of Acids.

Q. What is meant by an Acid?

A. By acids are meant, in common discourse, those substances which produce that sensation on the tongue termed *sour:* with acids, however, are classed several substances without this characteristic; but possessed of some of the other properties of acids.

Q. What do you observe of the properties of acids?

A. Acids have the property of changing the blue, green, and purple juices of vegetables to red; and of combining with alkalies, earths, or metallic oxides, so as to compose those compounds termed *salts.*

Q. From what do acids originate?

A. The greater part of the acids originate from the combination of oxygen with certain substances, which is termed the acidifying principle; but there are some substances that possess acid properties, which contain no oxygen.

Q. How many classes of acids are there?

A. Formerly the classes of acids were three; but the most scientific way of dividing them, is into two only: acids which have not been decomposed, or have been resolved into two principles, are of the first class; those which consist of more than two are of the second.

Q. What acids compose the first class?

A. The acids forming the first class are the sulphuric and sulphurous; muriatic and oxygenized muriatic, nitric, carbonic, phosphoric, and phosphorus, fluoric, boracic, arsenic, and arsenous, tungstic, molybdic, and molybdous, telluric, and chromic acids.

Q. What are the acids forming the second class?

A. The acids forming the second class, are the acetic, oxalic, tartaric, citric, malic, lattic, gallic, mucous, benzoic, succinic, camphoric, suberic, laccic, prussic, sebacic, uric, amniotic, and the fluoboric acids.

Q. What is *Sulphuric* acid?

A. Sulphuric acid is composed of sulphur and oxygen, and is commonly called oil of vitriol.

Q. How is it obtained?

A. Sulphuric acid is procured by burning sulphur in contact with oxygen; by this means the sulphur unites with the oxygen, and is acidified.

Q. If sulphuric acid is only sulphur and oxygen, how do you account for its fluidity?

A. Sulphuric acid, on being formed, is in a gaseous state; therefore the manufacturers condense it by means of water, and thus is formed the sulphuric acid of commerce, which is always fluid.

Q. What are the properties of sulphuric acid?

A. It is a ponderous and corrosive acid; and when combined with the alkalies and earths forms the salts called *sulphates.*

Q. What is the Sulphurous acid?

A. Sulphurous acid, like the sulphuric, is a combination of sulphur and oxygen, but with a greater proportion of sulphur than the latter.

Q. What are the properties of sulphurous acid?

A. Sulphurous acid in the gaseous state is possessed of a strong suffocating smell. When absorbed by water it forms liquid sulphurous acid. It is capable of combining with various bases, and forms the salts called *sulphites.*

Q. How is Muriatic acid obtained?

A. Muriatic acid, by means of sulphuric acid, is distilled from sea-salt; and being collected in proper receivers, is condensed in water.

Q. What are the properties of muriatic acid?

A. Muriatic acid in a gaseous state, like air, is invisible: with water it forms the liquid muriatic acid, which preserves the smell of the gas, and exhales white fumes when exposed to the atmosphere. It combines with various bases and forms the salts called *muriates.*

Q. What is Oxymuriatic acid?

A. Oxymuriatic acid, or chlorine, is a simple substance: it exists both in the gaseous state and combined with water, but it is in the latter form that it is generally used by artists.

Q. What have you to remark of the properties of oxymuriatic acid?

A. Oxymuriatic acid gas is of a suffocating nature; and it cannot, without great injury, be breathed; it however maintains combustion; it discharges vegetable colors, burns all the metals, and is the only acid capable of dissolving gold and platina.

With various bases it forms salts called *muriates.*

Q. What is the Nitric acid?

A. Nitric acid is compounded of oxygen and nitrogen, in the proportion by weight of about 26 parts of the latter to 74 of the former, and is one of the constituent parts of salt-petre.

Q. By what means is nitric acid obtained?

A. Nitric acid may be procured by distilling two parts of nitric with one of sulphuric acid, in a glass retort: while the fluid is collected in receivers, the acid containing nitrous acid, is at first of a deep red color, but on the subsequent application of heat, it becomes transparent and colorless.

Q. What properties has nitric acid?

A. When in a pure state, nitric acid is clear and colorless; the smell is pungent, and the taste extremely acrid; it has a great affinity for water, and can oxydize most metals with various bases: it forms the salts termed nitrates.

Q. What is *Nitrous* acid?

A. Nitrous acid is improperly so called, being, in fact, nitric acid impregnated with some portions of nitrous acid gas.

T. Describe the properties of nitrous acid.

P. In its properties, nitrous acid is something similar to nitric acid; but, according to the quantity of nitrous gas and of water with which it is combined, the color varies.

Q. What do you mean by *Carbonic* acid?

A. Carbonic acid is composed of carbon and oxygen, and was formerly called fixed air, as it is

intimately combined with certain substances, as chalk, lime-stone, and magnesia.

Q. What are the properties of carbonic acid?

A. In its gaseous form, carbonic acid is invisible, and unfit for respiration or combustion: it combines with alkalies, earths, and metallic oxides; and thus forms those salts termed *carbonates.*

Q. What do you observe of Phosphoric acid?

A. Phosphoric acid is compounded of oxygen, and the inflammable substance phosphorus.

Q. How is this acid obtained?

A. The only mode of procuring phosphoric acid formerly, was by burning phosphorus in oxygen gas; but now it is known that the acid is a constituent part of bones, and a much more economical way of obtaining it is from them.

Q. What do you observe of this acid?

A. Phosphoric acid is soluble in water; the solution being colorless, and of a strong acid taste; it combines with earthy, alkaline, and metallic bases; composing that variety of salts called *phosphates.*

Q. What is Phosphorous acid?

A. Phosphorous acid contains a minuter portion of oxygen than phosphoric acid, and is obtained by the slow combustion of phosphorus; which, when heated, burns very rapidly, and produces phosphoric acid.

Q. What do you observe of the properties of phosphorous acid?

A. Phosphorous acid is liquid, but of great density, its taste is acid: and its smell, when heated, similar

to that of garlic. The salts formed with it are called *phosphites*.

Q. What is *Fluoric* acid?

A. Fluoric acid is obtained from the fluate of lime: it is also found in *cryolite*, a rare mineral in West Greenland: the topaz, too, contains fluoric acid, though in a less proportion.

Q. What are the properties of fluoric acid?

A. It is readily absorbed by water, and forms liquid fluoric acid. In combination with the alkalies and earths, it forms the salts called *fluates*.

Q. For what purpose is fluoric acid used?

A. Fluoric acid has been employed for etching on glass, and for destroying the polish upon glass, so as to render it nearly opaque.

Q. What do you observe of Fluoboric acid?

A. It is an acid that is neither interesting nor useful, and is a compound of the boracic and fluoric acids.

Q. What is Boracic acid?

A. Boracic acid is an acid obtained from a substance known by the name of borax: its most peculiar property is that of giving a green color to all burning bodies. With the alkalies and earths it forms the salts called *borates*.

Q. What do you mean by Arsenic acid?

A. Arsenic acid, composed of arsenic and oxygen, is of a ponderous, thick mass, and poisonous in the highest degree. With different bases it forms the salts called *arseniates*.

Q. What is Tungstic acid?

A. Tungstic acid, composed of tungsten and

oxygen, is a tasteless yellow powder, soluble in hot water; and when united with earths, alkalies, or metals, forms *tungstates*.

Q. What is meant by Molybdic acid?

A. Molybdic acid is composed of oxygen and molybdenum, and is a pale yellow powder. When combined with some bases, the compounds are called *molybdates*.

Q. What do you observe of Chromic acid?

A. This acid is composed of oxygen and chromium, has a rough, metallic taste, and is chrystallizable. It also forms with the earths and alkalies various salts called *chromates*.

Q. What is Acetic acid?

A. Acetic acid is chiefly procured from saccharine matters which have suffered a vinous fermentation.

Q. What are its properties?

A. This acid is a pleasant yellow liquor, known by the name of vinegar; but when distilled is quite colorless. With various bases it forms the salts called *acetates*.

Q. What is Oxalic acid?

A. Oxalic acid, called also *salt of sorrel*, and by some *acid of sugar*, is obtained by oxygen from sugar. It is composed of oxygen, hydrogen and carbon. In combinations with the earths, &c., it forms the salts called *oxalites*.

Q. What is meant by Tartaric acid?

A. Tartaric acid is obtained from the tartar of commerce; it crystallizes, and is much used in

medicine for acute fevers, scurvy, and hemorrhages. The salts formed of it are called *tartrates.*

Q. What do you observe of Citric acid?

A. Citric acid is a peculiar acid procured from lemons: it exists also in a disengaged state in fruits: it is very acid and soluble, and its crystallizations are beautiful. The salts formed with it are called *citrates.*

Q. What is Malic acid?

A. This acid is produced from the juice of apples, gooseberries, barberries, &c., and is of an unpleasant sour taste, and incapable of crystallization. The salts formed with it are called *malates.*

Q. What is lactic acid?

A. Lactic acid is procured from the milk which has lost the curd: it is of a yellowish color, and cannot be crystallized. The salts formed with it are called *lactates.*

Q. What is meant by Gallic acid?

A. Gallic acid is a peculiar acid extracted from nutgalls, and possesses the property of precipitating iron, when dissolved in acids, of a blackish color. Its salts are called *gallates.*

Q. What is Mucous acid?

A. Mucous acid, or as it has been termed, saccholactic acid, is obtained by nitric acid from sugar and milk, gum arabic, and other mucilaginous substances: it is a white gritty powder, and its taste is slightly acid. Its salts are called *mucites.*

Q. What do you mean by Benzoic acid?

A. Benzoic acid is obtained by boiling the resin

benzoin in water: it is a light whitish powder, of a pleasant aromatic odor. It is used in medicine under the name of flowers of Benjamin. It forms the salts called *benzoates.*

Q. What do you observe of Succinic acid?

A. Succinic acid exists in a solid form, and is prepared from amber. It salts are called *succinates.*

Q. What do you mean by Camphoric acid?

A. Camphoric acid is obtained from camphor in white crystals, by means of nitric acid: its taste is acid and slightly bitter, with a smell similar to saffron. With salifiable bases it forms *camphorates.*

Q. What is Suberic acid?

A. This acid is procured by means of nitric acid from cork: it has an acid taste, and is incapable of crystallization. Its salts are called *suberates.*

Q. What is meant by Laccic acid?

A. Laccic acid is a peculiar acid, obtained from white lac: it is of a reddish color, and has a saline bitter taste.

Q. What do you observe of Prussic acid?

A. Prussic acid is a colorless fluid; it has a strong odor, and a sweetish but acrid taste. It is composed of hydrogen, nitrogen, and carbon, and is obtained from blood, and other animal substances: when combined with iron it forms what is called Prussian blue.

Q. What is Sebacic acid?

A. This acid is obtained from tallow, in the form of a liquid; and has an acid, sharp, bitter

taste: when combined with nitric acid, it dissolves gold; when united with alkalies and earths it forms the salts called *sebates*.

Q. What is Uric acid?

A. Uric or *lithic acid*, is procured from human urine, and has neither taste nor smell; being capable, however, of turning vegetable blues red: it is composed of carbon, nitrogen, hydrogen, and oxygen.

Q. What do you observe of Amniotic acid?

A. This acid is obtained from the liquor of the amnios of the cow, is slightly acid, and reddens the tincture of litmus: it unites with the pure alkalies and forms neutral salts.

Q. What have you to remark on the different uses of the acids?

A. Acids are indispensably necessary in arts and manufactures; they are also used for culinary purposes, and for medicine.

CHAPTER IX.

Of Salts.

Q. WHAT do you mean by Salts?

A. Salts, or saline substances, are formed when an acid combines with an earth, alkali, or metallic oxide: this composition was formerly called *neutral salts;* but those salts only are termed so now, that have neither an excess of acid or base.

Q. What number of salts do you observe?

A. The exact number of salts is not known, but they are supposed to amount to many hundreds.

Q. How are the different salts distinguished?

A. Every salt has a double name; one indicates its acid, the other its base: thus, in many hundred different salts their composition is instantly known by the appellation.

T. Describe how this is effected.

P. All substances composed of metallic oxides, earths, or alkalies with sulphuric acid, are termed *sulphates;* with muriatic acid, *muriates;* with nitric acid, *nitrates;* with carbonic acid, *carbonates,* &c.

Q. What term is used for common salt?

A. Common salt is called *muriate of soda,* from its being composed of soda and muriatic acid.

Q. What is salt-petre called?

A. Salt-petre is called *nitrate of potash,* as its constituent parts are nitric acid and potash.

Q. What term is used for chalk?

A. Chalk is termed *carbonate of lime,* being a compound of lime and carbonic acid.

Q. If these bodies were formerly termed *neutral salts,* why is not the same name still applied to them?

A. No salt can be considered strictly neutral, that possesses a taste of either the acid or the base of which it is formed.

Q. Is this generally the case?

A. There are some which have an excess of acid, as the supertartrate of potash, (cream of tartar,)

and the greater part of the metallic salts; some have a greater proportion of base, as borax.

Q. By what means are such salts distinguished?

A. If a salt is found to possess a superfluity of acid, the word *super* is applied to its name, as super-tartrate of potash; if on the contrary, it contain an insufficiency of acid to saturate it, the word *sub* is applied, as sub-borate of soda.

Q. How do you distinguish salts, of which the acids are not perfectly oxygenized?

A. All salts that are composed from acids terminating in *ous*, and in *ite* instead of *ate*, as *sulphite* of lime or *phosphite* of potash.

Q. What are the changes to which the salts are subject?

A. Salts are subject to the following changes; *deliquescence*, *efflorescence*, *solubility*, and *fusibility*.

Q. What do you mean by deliquescence?

A. There are some salts with such an affinity for water, that they absorb it from the atmosphere, and by that means become liquid or moist, which is termed deliquescence.

Q. What is efflorescence?

A. When a salt has a less affinity for water than for atmosphere, it loses its water of crystallization, and becomes a powder.

Q. What is solubility?

A. By solubility is meant the capacity that a salt has for uniting with water, and being contained in it in a state of solution.

Q. What is fusibility?

A. Fusibility is the property of melting, on the application of great heat.

CHAPTER X.

Of Simple Combustibles.

Q. WHAT do you mean by a simple substance?

A. Those are termed simple substances which have never been either decomposed or artificially formed.

T. Enumerate the simple substances.

P. The simple substances with which we are acquainted, are electricity, magnetism, caloric, light, chlorine, oxygen, nitrogen, iodine, the metals, and the simple combustibles, such as phosphorus, sulphur, carbon, hydrogen, boron, and fluorine.

Q. What is to be understood by simple combustibles?

A. When we have no proof of their being compounded, combustibles are termed simple; whereas, wax, oil, tallow, and other combustible bodies, are composed of two or more ingredients.

Q. What is Hydrogen?

A. Hydrogen is a simple substance, which from its property of burning with vital air, has been termed *inflammable air;* also, combined with oxygen it forms water.

Q. What do you mean by sulphurated hydrogen gas?

A. This gas is transparent and colorless; it is inflammable, and has all the characters of an acid.

Q. What is phosphuretted hydrogen gas?

A. If hydrogen gas be combined with phosphorus, phosphuretted hydrogen gas will be obtained, which takes fire the instant that it comes in contact with atmospheric air.

Q. How is Carburetted Hydrogen gas produced?

A. This gas is formed by carbon being dissolved in hydrogen: it is this gas which causes many dreadful accidents in mines and coal-pits; and which by the miners is termed *fire-damp.*

Q. What are the chief uses of carburetted hydrogen gas?

A. From its inflammability and brilliant flame, this gas has been used for lighting streets, shops, manufactories, and light-houses on the sea-coast; and the rate at which it is procured is trifling compared with the expense of oil or tallow.

Q. What is Sulphur?

A. The earth abounds with Sulphur, both pure and in a state of combination: it is of a light lemon color, very brittle, and when heated, emits a very disagreeable and unwholesome smell. Its specific gravity is 1·99.

Q. What do you observe of Phosphorus?

A. Phosphorus is one of the most combustible substances known, and is of a yellowish color.

Q. How is phosphorus obtained?

A. Phosphorus is a substance both animal and

mineral, and is obtained by decomposing the phosphoric acid contained in bones.

Q. What else do you observe of phosphorus?

A. Phosphorus is so inflammable, that at a very low temperature it spontaneously takes fire, and burns rapidly with a brilliant white flame. It is a solid substance, and its specific gravity is nearly twice that of water.

Q. What is Carbon?

A. Carbon, or *charcoal*, is the black residue of vegetable substances, the volatile properties of which have been entirely dissipated by heat; but pure carbon is known only in the diamond.

Q. What compounds are obtained by means of carbon?

A. Various combinations are formed by means of carbon, from its uniting with oxygen, hydrogen, nitrogen, phosphorus, sulphur, and iron.

T. Describe these compounds.

P. With various portions of oxygen, carbon composes carbonic acid; with hydrogen and caloric, carburetted hydrogen gas, &c.

Q. What is meant by Charcoal?

A. Charcoal, the most familiar combination of carbon, is the residuum of vegetable substances burnt in close vessels.

Q. What is the use of charcoal?

A. Charcoal is greatly used in making gunpowder, for decomposing sulphuric salts; also in manufactures, and by chemists.

Q. Is charcoal a simple or a compound substance?

A. Common charcoal is a compound substance:

—it is an oxide of iron;—it also contains hydrogen, and a portion of alkaline salt and some earth.

Q. What do you observe of *pure* carbon?

A. Carbon, when crystallized, is called *diamond;* but its crystallization by art has never yet been effected.

Q. Of what use is carbon in vegetables?

A. Carbon composes nearly the whole basis of vegetables, from a flower to a tree.

Q. Does carbon enter into the composition of minerals?

A. We know only of its combination with iron.

Q. What is formed when carbon combines with iron?

A. In one proportion, cast iron is formed, in another steel—in another plumbago; commonly called *black-lead.*

Q. What is the proportion of carbon in cast iron?

A. Cast iron contains about one forty-fifth of its weight in carbon.

Q. What is the proportion of carbon in steel?

A. Steel contains about one part of carbon to two hundred parts of iron.

Q. What is the proportion of carbon in plumbago?

A. Plumbago contains about nine parts of carbon to one of iron.

Q. How is Carbonic acid generally obtained?

A. Carbonic acid is obtained from the decomposition of vegetables, from the surface of fermented liquors, and by pouring sulphuric acid upon chalk or marble.

CHAPTER XI.

Of Metals.

Q. How are metals distinguished?

A. Metals are distinguished by their specific gravity, opacity, and peculiar brilliancy.

Q. How are they obtained?

A. Metals are dug out of the earth, but very seldom in a state of purity.

Q. What number of metals are there.

A. The number of metals is 42, which essentially differ from each other.

T Give the names of some of them?

P. Platina, gold, silver, copper, iron, lead, tin, zinc, mercury, tellerium, antimony, bismuth, manganese, nickel, nickolinum, cobalt, uranium, titanium, columbium, chrome, molybdenum, tungsten, arsenic, tantalium, cerium, palladium, rhodium, iridium, and osmium.

Q. What is Platina?

A. Platina is the hardest and heaviest of all metals, and is found in the North of Peru, and at Carthagena in South America; it is white and hard, of great tenacity and ductility, and is with difficulty reduced to fusion; on which account it is sometimes used for chemical instruments. Its specific gravity is 21.

Q. What is Gold?

A. Gold is a metal of a yellow color and great lustre: it is the most ductile and unchangeable

of all metals; and is incapable of combustion by the ordinary action of fire, or by any other means, indeed, than galvanism, or exposure to oxygen and hydrogen. Its specific gravity is 19.

Q. Where is gold obtained?

A. Gold is found in Africa, Hungary, Spain, France, and in North and South America.

Q. What are the uses of gold?

A. Gold is chiefly used for plate, jewelry, and for current coin; but for these purposes it is generally alloyed with a portion of silver or copper: it is also employed in various arts.

Q. What are the peculiar properties of gold?

A. Gold, from its great ductility and tenacity, may be beat into leaves so thin, that it would take 282,000 to make an inch in thickness.

Q. What are the qualities of Silver?

A. Silver is of a white color, unalterable by fire, and very tenacious. Its specific gravity is 10·50.

Q. Where is silver found?

A. Mexico, Bohemia, Transylvania, and many other countries, abound with silver mines.

Q. What are the peculiar properties of silver?

A. Silver also, from its peculiar ductility and tenaciousness, may be beat into leaves of one hundred and sixty thousandth part of an inch thick, and drawn into wire a thousandth part of an inch.

Q. What effect has oxygen upon silver?

A. Silver is not oxydized by atmospheric air, unless exposed to an intense heat; but the oxyde of silver may be obtained by dissolving the metal

in an acid, and precipitating it by means of lime-water, or an alkali.

Q. What do you observe of the uses of silver?

A. Silver is principally used for ornamental work, current coin, and for forming domestic utensils; and is generally alloyed with a portion of copper in order to harden it.

Q. What is Copper?

A. Copper is a metal of a rose red color, very sonorous and ductile: it was first discovered in the Island of Cyprus, but is now abundantly found in different countries. Its specific gravity is 8·90.

Q. What Salts are there of copper?

A. Among the salts of copper are the sulphate of copper, acetate of copper, nitrate, muriate, and arseniate of copper, &c., which are generally formed by art.

Q. Are there no native salts of copper?

A. The native salts of copper are the carbonate, the arseniate, the muriate, the sulphate and the phosphate of copper.

Q. What are the qualities of Iron?

A. Iron is a pale white color; it is found very abundantly in nature, and is distinguished from every other metal by its magnetical properties. Its specific gravity is 7·78.

Q. What is Steel?

A. Steel is iron combined with carbon, is of a light gray color, and susceptible of the most brilliant polish.

Q. How do iron and carbon form steel?

A. Bars of malleable iron and charcoal are placed in layers, in a close furnace, and a strong fire is applied for a week or ten days; it is then drawn out, and, when cold, beat with a hammer, or cast into small bars, forming what is called *cast steel.*

Q. What properties has Lead?

A. Lead is of a light gray color; it is the softest and least sonorous of metals, is fusible by gentle heat, and tarnishes on exposure to the atmospheric air. Its specific gravity is 11·35.

Q. What are the characters of Tin?

A. Tin is of a brilliant light color, and one of the lightest of metals: it is obtained in great quantities from the mine in Cornwall, England. Its specific gravity is 7·30.

Q. What are the qualities of Zinc?

A. Zinc, after iron, is the most common of metals; it is of a brilliant bluish white color; and in its natural state is combined with oxygen and carbonic and sulphuric acid.

Q. What is Mercury?

A. Mercury, or quicksilver, is a substance of the color of silver, and is the only metal that remains fluid at the ordinary temperature of the atmosphere; when reduced, however, to 40° Fahrenheit, it assumes a solid form. Its specific gravity is 13·50.

Q. What is Tellurium?

A. Tellurium is a metal of a white color, similar to tin, and is possessed of considerable metallic lustre. Its specific gravity is 6·10.

Q. What qualities has Antimony?

A. Antimony is very brilliant; its color is white, being intermediate between those of tin and silver; and it is but rarely found native. Its specific gravity is 6·70.

Q. What properties has Bismuth?

A. Bismuth is of a reddish white color; and is so brittle, that it may be reduced to a powder. Its specific gravity is 9·80.

Q. What are the qualities of manganese?

A. Manganese is of a grayish color, very hard and brittle; and is the most combustible of all metals. Its specific gravity is 6·85.

Q. What is Nickel?

A. Nickel, when free from heterogeneous substances, is of a pale flesh color, is of a fine compact texture; and when newly broken, has a strong lustre. Its specific gravity is 8·25.

Q. What qualities has Nickolinum?

A. Nickolinum bears a resemblance to nickel from its magnetical powers; but, unlike nickel, it requires combustible bodies to dissolve it.

Q. What are the properties of Cobalt?

A. Cobalt, in its pure state, is of a steel gray color, inclining to red; is obedient to the magnet, and is very brittle; with ease it may be reduced to a powder. Its specific gravity is 8.

Q. What characters has Uranium?

A. Uranium is a mass of small metallic globules adhering together, of a deep gray color on the outside, and within of a pale brown; it is so soft that it may be scraped with a knife. Its specific gravity is 9.

Q. What is Titanium?

A. Titanium is of a red yellow crystalline texture, and very brittle; it resembles copper, and possesses much lustre; but tarnishes when exposed to the air.

Q. What qualities has Columbium?

A. Columbium or tantalium is of a dark gray color; incapable of being reduced by the most intense heat, but may be pulverized in a mortar; even in that state, however, it cannot be affected by an acid.

Q. What qualities does Chrome possess?

A. Chrome is a metal of a grayish color, very brittle, and capable of being crystalized at a high temperature.

Q. What are the properties of Molybdenum?

A. Molybdenum is obtained from a mineral in Sweden; it is of a silver like color, and very brittle. Its specific gravity is 7·40.

Q. What is Tungsten?

A. Tungsten is of a steel gray color; one of the hardest metals, but extremely brittle. Its specific gravity is 17·50.

Q. What qualities has Arsenic?

A. Arsenic is of a lively bright color, very brittle, and is extremely poisonous. Its specific gravity is 8·35.

Q. What are the properties of Tantalium?

A. Tantalium is of a grayish color, and may be distinguished from all other metals by its insolubility in acids, and its being acted upon by alkalies.

Q. What is Cerium?

A. Cerium is a metal obtained from a fossil found in Sweden, named cerite; but the quantities hitherto discovered have been too small to admit of its properties being accurately determined.

Q. What are the characters of Palladium?

A. Palladium in some measure resembles platina, but is of a duller color; it possesses great malleability, and may be drawn into wire of great fineness. Its specific gravity is 11·50.

Q. What properties has Rhodium?

A. Rhodium is a yellowish metal, and in some degree resembles silver. It is as hard as iron, but much more brittle.

Q. What qualities has Iridium?

A. Iridium is a white metal, resembling platina; it is very brittle and infusible, but may be dissolved in muriatic acid.

Q. What are the qualities of Osmium?

A. Osmium is a metal of a blue color, is with difficulty fusible by a great heat, and is insoluble in acids.

Q. What is Potassium?

A. Potassium is an alkaline metal, perfectly white, has the brightness of silver, and possesses a greater affinity for oxygen than any other body. Its specific gravity is 0·86.

Q. What is Sodium?

A. Sodium, another alkaline metal, has similar properties to potassium; is white and bright like silver, and very malleable. Its specific gravity is 0·97.

CHAPTER XII.

Of Oxides.

Q. WHAT is an Oxide?

A. An Oxide is a substance whose base is composed of less oxygen than is sufficient to convert it into an acid.

Q. Of what substances are oxides composed?

A. Oxides are formed by a union of oxygen with animal, mineral, and vegetable productions.

Q. By what means do oxygen and metals unite?

A. The chief cause of union is from the decomposition of acids and of water, or by access of atmospheric air.

Q. Are metals ever exposed to the air for the purpose of converting them into oxides?

A. The common red lead, which is the true oxide of lead, is made by melting that metal in ovens so constructed as to have a free access of air.

Q. What metals become oxides by the decomposition of water?

A. Zinc, tin, iron, and manganese become oxydized by the decomposition of water.

Q. What quantity of oxygen is requisite for the oxydizing of metals?

A. Metals become oxydized by different proportions of oxygen, according to the manner of effecting it, and the degree of force with which it retains oxygen.

Q. Are acids often necessary for the oxydizing of metals?

A. There are many examples of metals being oxydized by the agency of metals; common white lead, for instance, is obtained by exposing sheet-lead to the fumes of acetic acid.

Q. What do you observe of the properties of metallic oxides?

A. Metallic oxides are heavier than the metals from which they are produced, and in combination with different acids form metallic salts.

Q. Is it possible to reduce metallic oxides?

A. Charcoal, on account of its affinity for oxygen, is frequently used for that purpose; though, from the slight union of some metals with oxygen, light alone will effect it, by attracting the oxygen.

Q. What is Carbonic oxide?

A. Carbonic oxide is obtained by heating charcoal with metallic oxides; in which case it absorbs the oxygen and becomes a gas.

Q. What are its properties?

A. Carbonic oxide, like most other gases, is invisible; it is very offensive to the smell, and is highly combustible.

Q. What is Nitrous oxide, and how is it obtained?

A. Nitrous oxide is composed of 63 parts of nitrogen and 37 parts of oxygen by weight; and is obtained by exposing crystals of the nitrate of ammonia to heat in a retort: the salt assumes its constituent parts, and the gas is evolved.

Q. What are the properties of this gas?

A. Nitrous oxide, more than any other gas, re-

sembles atmospheric air; it is respirable, and so pure that the effects produced on people who have inhaled it, have been of the most pleasing and rapturous kind.

Q. What is Nitric oxide, and how is it obtained?

A. Nitric oxide is composed of 47 parts of nitrogen and 53 parts of oxygen, and is obtained by dissolving copper or mercury in nitric acid, and collecting the gas which rises from the solution.

Q. What else do you observe of nitric oxide?

A. Nitric oxide can in some instances support combustion; but, in none, life: it is heavier than atmospheric air; and, by mixing this gas and oxygen gas together, nitric acid is formed.

CHAPTER XIII.

Of Combustion.

Q. WHAT do you mean by Combustion?

A. By combustion is meant a decomposition of the oxygen gas in such substances as are capable of being separated by burning, the base of the oxygen being absorbed, and its caloric escaping as sensible heat.

Q. Can all substances be burned?

A. Only some substances are combustible; others cannot be burned.

Q. What are simple combustibles?

A. The simple combustibles, that is, such as

have not been decomposed, are sulphur, hydrogen, phosphorus, carbon, boron, and the different metals.

Q. What are compound combustibles?

A. Compound combustibles are formed by a union of two or more of the simple combustibles.

Q. What is meant by the supporters of combustion?

A. The supporters of combustion are those substances which are not themselves combustible; but without the presence of one of which, combustion cannot happen.

Q. What are supporters of combustion?

A. The supporters of combustion are oxygen gas, chlorine gas, and iodine.

Q. How is oxygen a supporter of combustion?

A. From its affinity for combustible substances, oxygen promotes combustion; for when bodies are burning, they absorb oxygen form the air, or from other subjects in contact with them.

Q. How do you account for the heat which is observed during combustion?

A. The heat produced by combustion, arises from the decomposition of oxygen gas contained in the atmosphere; for as the oxygen combines with the combustible, caloric is given out in the form of sensible heat in every direction.

Q. During combustion, what does the light proceed from?

A. The light and flame which appears during the combustion, is supposed by some to proceed from the decomposition of atmospheric air, and

by others as proceeding from the combustible body.

Q. How is chlorine gas a supporter of combustion?

A. If tin, zinc, copper or iron filings be thrown into chlorine gas, they burn spontaneously, and what is produced from the combustion, is called a chloride.

Q. In what manner is iodine a supporter of combustion?

A. If in the common temperature of the atmosphere, phosphorus comes in contact with the crystals of iodine, heat will be evolved, but no light.

Q. How do combustibles differ from each other?

A. Combustibles differ principally from each other, from the avidity they have for the absorption of oxygen.

Q. Is any part of bodies destroyed by combustion?

A. It is supposed that every particle of matter is indestructible, and that the process of combustion merely decomposes the body.

CHAPTER XIV.

Of Attraction, Repulsion, and Chemical Affinity.

Q. WHAT do you mean by attraction?

A. Attraction is that property of matter, by which its particles are made mutually to approach and unite to one another.

Q. What are the most striking instances of attraction?

A. The most striking instances of attraction are that of all bodies to the centre of the earth, called *attraction of gravitation;* magnetism, electricity, galvanism, and that of the planets toward one another.

Q. How is attraction defined by chemists?

A. When the force of attraction operates between particles of the same body, it is termed attraction of *cohesion*; but when between the particles of different bodies, it is termed attraction of *composition*, or chemical affinity.

Q. What do you mean by attraction of cohesion?

A. The particles of every body attract one another, so that they unite into one substance.

Q. What is chemical affinity?

A. Attraction of composition, chemical affinity, or elective attraction, is the tendency of certain bodies to unite with others, and form one compound.

Q. What do you observe of the laws of chemical attraction?

A. Chemical attraction must exist between parts of opposite and distinct substances, and is proportionable to the different force exerted in such substances.

Q. What is meant by simple attraction?

A. Simple attraction is when two bodies unite by their mutual attraction.

Q. What do you mean by compound affinity?

A. Compound affinity is the mutual action of two compound bodies, by which means they decompose each other, and produce other compounds.

Q. What is disposing affinity?

A. Disposing affinity is when two bodies, which appear to have no tendency to unite, combine on the addition of another substance.

Q. What benefit arises from a knowledge of attractions?

A. By a knowledge of the attraction which one body has for another, we are enabled to analyze the productions of nature.

Q. What is meant by repulsion?

A. Repulsion is a certain power which all bodies possess, and which gives them a tendency to recede from each other.

Q. What proofs are there of repulsion?

A. The existence of a force, that opposes the approach of bodies, is beyond a doubt; but the cause is as unknown as that of attraction: the only kinds of repulsion, perceptible to the senses, are electricity and magnetism.

APPENDIX.

Simple and Amusing Experiments.

CHAPTER I.

ON TEMPERATURE.

I. *To produce Heat by Water and Sulphuric Acid.*

TAKE two phials, and in one of them put a little sulphuric acid, and let the other be half filled with water; grasp the phial containing the water, firmly in one hand, and with the other gradually pour a little of the sulphuric acid into it, and sufficient heat will be produced to boil an egg.

II. *To freeze Water in Summer.*

Suspend with a string a glass tube having a bulb; fill the whole with water, and keep the bulb moist with pure sulphuric ether; and the water will in a short time, become ice.

III. *Cold produced.*

Take a bottle and put a little powdered muriate of ammonia, and hold it fast, as in the first experiment, in one hand, and pour some cold water into it, when a degree of cold will be produced equal to that of ice or snow.

IV. *Heat by the Formation of a Salt.*

Put a small thermometer in a glass vessel containing two ounces of soda, then add as much muriatic acid as will saturate the soda; this will immediately produce heat, so that the mercury will rise or expand.

V. *Cold by Formation of Salt.*

Place a small thermometer in a glass vessel, with about an ounce of the carbonate of soda, then add muriatic acid till the soda is saturated; cold will be produced, so that the mercury will fall in the thermometer

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CHAPTER II.

ON THE GASES.

VI. *To produce Carbonic Acid Gas.*

Put into a common bottle a small quantity of marble or chalk roughly powdered, and pour upon

it some sulphuric acid, diluted with two parts water; a great effervescence will take place, and *carbonic gas* will be evolved.

VII. *To produce Oxygen Gas.*

Put a small quantity of the black oxide of manganese into a retort, and pour on it some sulphuric acid; apply heat, and you will attain *oxygen gas.*

VIII. *Nitric Acid Gas produced.*

Put into a retort some nitrate of potash, (saltpetre,) pour upon it some sulphuric acid and apply the heat of a lamp, and *nitric acid gas* will then be disengaged.

IX. *Hydrogen Gas evolved.*

Put some iron filings or pieces of zinc into a bottle, pour on them some sulphuric acid mixed two parts with water, and *hydrogen gas* will be the produce.

X. *Principal of the Air Balloon.*

Fill with hydrogen gas a bladder having a stopcock, and apply it to a tobacco-pipe; having dipped the bowl of the pipe into a lather of soap, press the bladder, and bubbles of soap, containing hydrogen gas, will ascend, similar to an air balloon.

XI. *To produce an Explosion.*

If a bladder, such as described in the preceding experiment, be filled with *oxygen* as well as *hydrogen*, and the bubbles, as they ascend, be touched with lighted paper, they will explode with a loud noise.

XII. *Nitrous Gas produced.*

If some small shreds of copper be put into a phial, and some diluted *nitrous acid* poured upon them, *nitrous gas* will be produced.

XIII. *To produce Muriatic Acid Gas.*

Pour some *sulphuric acid* on some common salt, and *muriatic acid gas* will be evolved.

XIV. *To form a beautiful Flame.*

If a bladder (furnished with a stop-cock) be filled with hydrogen gas, on compressing it and applying a lighted candle to the end of the pipe, a beautiful stream of flame will be seen issuing from it.

XV. *To procure Charcoal.*

Having put a little phosphorus into a crucible, cover it closely with powdered chalk till the crucible is filled: invert another crucible, then apply fire till they are red hot: when the mixture is cold, charcoal will be found.

CHAPTER III.

FORMATION OF SALTS.

XVI. *Atmospheric Air necessary in Crystallization.*

PROCURE a two ounce phial, and put into it an ounce of Glauber's or Epsom salts, pour a little boiling water on them, and tie the mouth of the phial with a piece of moistened bladder, so as to exclude all air; when perfectly cold, the contents will have the appearance of cold water, but on puncturing the bladder the whole will become immediately crystallized.

XVII. *How to form common Table Salt.*

Take two ounces of soda, and saturate it with muriatic acid; both of which are corrosive articles; the compound substance produced will be the mild and useful common salt.

XVIII. *To form another solid crystalline mass.*

Take two wine-glasses, into one of them put a solution of carbonate of potash, and into the other a similar quantity of the solution of muriate of lime; mix the two together, constantly stirring them, and a solid mass will be obtained from the mixture.

CHAPTER IV.

ON COLORS.

A number of very innocent and pleasing experiments upon colors, may be performed, by the following preparations.

No. 1.

DISSOLVE a dram of the acetite of lead in six ounces of water, and filter the solution.

No. 2.

Dissolve an ounce and a half of the carbonate of potash in a similar quantity of water, and filter the solution.

No. 3.

Dissolve 10 grains of corrosive muriate of mercury in six ounces of water, and filter the solution.

No. 4.

One ounce of sulphate of iron to be dissolved in six ounces of water, and filtered.

No. 5.

Take a similar solution, prepared as above, and add to it half an ounce of sulphuric acid.

No. 6.

Mix half an ounce of sulphuric acid with six ounces of water.

No. 7.

Dissolve half a dram of crystallized acetite of copper in six ounces of water.

No. 8.

Concentrated quantity of liquid ammonia.

No. 9.

Sulphurous acid.

No. 10.

Some red-rose leaves infused in sulphurous acid.

No. 11.

Red cabbage leaves infused as above.

No. 12.

Digest half an ounce of bruised gall-nuts in 12 ounces of water, filter the solution, and then add one dram of nitric acid.

No. 13.

Diluted solution of potash.

No. 14.

Dissolve half a dram of quicksilver in two

drams of moderately strong nitric acid, mixing with the solution six ounces of water.

When these colorless Fluids are mixed together, the following tints may be procured.

XIX. *To form Milk-white.*

Mix three parts of No. 1 with one of No. 2.

XX. *To make Yellow.*

Four parts of No. 14 with one of No. 2.

XXI. *To produce Orange.*

Four parts of No. 3 with one of No. 2, and the mixture will be orange. If No. 6 be added, the mixture returns to its former limpid state.

XXII. *To make Carmine.*

Mix a few drops of No. 6, with No. 10; and by adding No. 9 this color disappears.

XXIII. *To form Blood-Red.*

A few drops of No. 6 with No. 11; it will become colorless, on adding No. 9.

XXIV. *To produce Grass-Green.*

Three parts of No. 10 with one of No. 1: on adding No. 6, the mixture becomes red; a few drops of No. 9 restore it to a colorless liquid.

XXV. *To make Light-Green.*

Three parts of No. 11 with one of No. 1.

XXVI. *To form Ultra-marine Blue.*

Mix three parts of No. 7 with one of No. 8: which again becomes colorless by adding No. 6.

XXVII. *To make Dark Blue.*

Mix three parts of No. 11 with one of No. 2; which changes to a ruby-red, on the addition of No. 6.

XXVIII. *To make Prussian Blue.*

Mix equal quantities of No. 5 and No. 13.

XXIX. *To make Violet.*

Mix equal quantities of No. 7 and No. 11.

XXX. *To form Dark Brown.*

To tincture of turmeric, add two drops of solution of potash, the original bright yellow color will be converted into a dark brown, but the color may be restored by applying a little colorless diluted acid.

XXXI. *To produce a colorless substance.*

Boil a small quantity of water, containing carbonate of iron in a state of solution, and add prussiate of potash; the mixture will have no color.

XXXII. *To form Pitch-Black.*

Mix three parts of No. 11. with one of No 4.

XXXIII. *To make Ink Black.*

Mix three parts of No 12, with one of No 4, which is again rendered limpid by No. 6; and No. 13 turns it blue.

XXXIV. *To make Golden Ink.*

Take white gum arabic, and reduce it to an impalpable powder in a morter, dissolve it in strong brandy, and add to it a little water: take some gold in a shell, and reduce it to powder, then moisten it with a gummy solution, and stir it; leave it for a night to dissolve the gold, dilute it with gum-water infused with a little saffron, then write with a common pen, and polish the writing with a piece of ivory, when the letters will be of a beautiful golden color.

XXXV. *Red Ink.*

Boil for a quarter of an hour two ounces of Brazil wood, with a pint of rain-water, and add to it a little alum, gum arabic, and sugar candy.

XXXVI. *Blue Ink.*

Indigo and ceruse diluted with gum-water will form blue ink.

XXXVII. *Yellow Ink.*

Dilute gamboge in gum-water, or saffron and yellow berries, (*graine d'Avignon.*)

XXXVIII. *Green Ink.*

Boil sap-green in water, with a little dissolved rock alum.

XXXIX. *To produce Black Writing.*

Write with the juice of onions, or lemon juice, and the writing will be invisible; but by holding it to the fire it will become black.

CHAPTER V.

COMBUSTION AND DETONATION.

XL. *To produce Fulminating Powder without danger.*

Mix six parts of nitrate of potash, and two of sulphur: rub them together in a warm mortar, the product will be what is commonly called *fulminating powder;* a small quantity of which, being put on the corner of a fire-shovel and held over the fire, gradually becomes black, and explodes with a loud denotating report.

XLI. *To produce Ignition by cold Mixture.*

Put a little magnesia into a cup, and pour sufficient concentrated sulphuric acid upon it to cover it; in an instant sparks will be given out, and the whole will become ignited.

CHAPTER VI.

PHOSPHORIC EXPERIMENTS.

XLII. *Phosphoric Writing.*

If a small piece of phosphorus be placed in a quill, and any characters written with it on a wall, when dark, they will become beautifully luminous.

XLIII. *To produce the appearance of Fire without danger.*

If the face or hands be rubbed with phosphuretted ether, in a dark place, they will appear as though on fire, without danger or sensation of heat.

XLIV. *To make a Basin of Water appear on Fire.*

If a lump of sugar be wetted with phosphorized ether, and thrown into a basin of water, the whole of the surface will be illuminated, resembling the fiery appearance of the sea.

XLV. *To produce flashes of Fire from Water.*

To a glass of water add phosphate of lime; in a short time, flashes of fire will dart from the surface, and end in ringlets of smoke, which will ascend in regular order.

XLVI. *To make a Luminous Phial to show the Hour in the Night.*

Put a piece of phosphorus into a phial, and fill it one-third with boiling olive oil, cork it tight: on the cork being removed, the light produced will be so strong as to show on a watch the hour of the night.

CHAPTER VII.

METALS.

XLVII. *To procure Sulphate of Silver.*

TAKE two glasses, each of them containing rain water, and put into one of them a single drop of sulphuric acid; and into the other put a little nitrate of silver, and no change will be discernible; but on mixing the two a precipitate will appear, which is *sulphate* of silver.

XLVIII. *Muriate of Silver and Sulphate of Silver.*

Procure two glasses, and fill them with rain water as above, and into one put a couple of drops of muriatic acid, and into the other some nitrate of silver; on mixing the two, a precipitate, consisting of *muriate of silver* and sulphate of silver, will be produced.

METALLIC VEGETATION.

XLIX. *Leaden Metallic Tree.*

Dissolve in a quart of water, about an ounce of acetate of lead, and filter the solution; if a piece of zinc be suspended in it by means of a piece of brass wire, a decomposition of the salt will immediately take place, and the lead will be at liberty, which will fix itself upon the wire, forming a *metallic tree.*

L. *Arbor Martis; or Tree of Mars.*

Dissolve iron filings in spirits of nitre (aqua fortis) moderately; stir it till the acid is saturated; then pour gradually into the solution a solution of fixed alkali, commonly called oil of tartar per deliquium; a strong effervescence will take place, and the iron, instead of falling to the bottom of the vessel, will afterward rise, so as to cover its sides, forming a multitude of ramifications heaped one upon the other, which will sometimes pass over the edge of the vessel, and extend

themselves on the outside, with all the appearance of a plant. If any of the liquor is spilled, it must be carefully collected and be again put into the vessel, where it will form new ramifications, which will contribute to increase the mass of the vegetation.

LI. *Arbor Dianæ; or Tree of Diana.*

Most metals are capable of decomposing a nitric solution of silver. The separation of the metal by mercury, on account of the phenomena which it presents, was been called Diana's Tree, or Arbor Dianæ.

Dissolve one part of fine silver in weak nitric acid to saturation; having diluted this solution with about twenty parts of distilled water, add two of mercury.

Another method is to make an alloy of four parts of silver leaf and two parts of mercury; to dissolve this alloy in a sufficient quantity of nitric acid, and to add to the solution distilled water.

On putting into this liquor a small ball of soft alloy of silver, a precipitation of silver immediately takes place.

Another way again is to mix six parts of a solution of silver and four of a solution of mercury, both made with nitric acid, and completely saturated; adding a little distilled water, and putting the mixture into a conical vessel, into which have been previously introduced six parts of an alloy consisting of seven parts of mercury and one of silver.

At the end of some hours there will be formed, at the surface of the alloy, vegetation in the form of a bush.

A process better than any of the former, is to dissolve three drams and 48 grains of pure silver, and half as much mercury, separately, in sufficient quantities of pure nitric acid; mix the solutions, and add five or six ounces of distilled water: this must be poured upon seven drams and 12 grains of an amalgam of silver, previously put into a spherical vessel of glass, and having the consistence of butter. The vessel being kept undisturbed, in about 24 hours a very beautiful silver tree will be formed.

REMARK.—In order to obtain a beautiful vegetation, it is absolutely necessary that all the ingredients be of the utmost purity: a cylindrical or conical glass vessel suits best.

LII. *Precipitation of Silver by Copper.*

Spread with a camel's hair pencil or feather, a few drops of a solution of silver in nitric acid, on a smooth piece of slate, or a plate of glass, place at the bottom in contact with the fluid, a copper or brass wire of about one-sixteenth of an inch in diameter, and let the whole remain undisturbed in a horizontal position. Under a glass magnifier, or microscope, appears a beautiful vegetation

LIII. *To make an Artificial Volcano.*

Take equal parts of pounded sulphur and iron filings, and after forming the whole into a paste

with water, bury a certain quantity of the composition, forty or fifty pounds for example, at about the depth of a foot below the surface of the earth. In ten or twelve hours, if the weather be warm, the earth will swell up and burst, and flames will issue out, enlarging the aperture, and scattering around a yellow and blackish dust.

It is not impossible that what is here seen in miniature, takes place on a grand scale in volcanoes; as it is well known that they always furnish abundance of sulphur, and that the articles which they throw up abound in metallic particles

LIV. *Silver Figures on Silk.*

Write or draw any characters or figures on silk and ribbon, with a solution of nitrate of silver, then moisten the silk with a little water, and expose it to the action of hydrogen gas, the silver will be revived, and the figures will be fixed on the silk, and shine with great brilliancy.

CHAPTER VIII.

SYMPATHETIC INKS, ETC.

LV. *Yellow Ink.*

WRITE a note or letter, with a solution of muriate of copper, and while cold the characters will

be invisible; but on exposing the paper to the heat of the fire, the writing will appear of a *yellow* color.

LVI. *Blue Ink.*

Proceed in the same manner with acetate of cobalt, and the writing, on being exposed to the fire, will appear of a *blue* color.

LVII. *Green Ink.*

Write with a solution of muriate of cobalt, and when cold the writing will be invisible; but on warming the paper the letters will be of a *green* color.

LVIII. *Silver Letters.*

If some lines be written with a solution of nitrate of silver, and then hold the paper over a vessel containing sulphate of ammonia, the letters will have the appearance of silver.

LIX. *Jet-Black Letters.*

If a letter be written with a solution of sulphate of iron, the writing will be invisible; but on washing it with a little decoction or infusion of gall-nuts, the letters will be of a *jet-black* color.

LX. *Letters of a Blue Color.*

Proceed as in the last, but instead of the infu-

sion of galls, use prussiate of potash, and the letters will be of a *blue* color.

LXI. *To make a Landscape alternately representing Winter and Summer.*

Form a landscape with common Indian ink, but paint the grass and leaves with muriate of cobalt; the picture will then represent a winter piece: on the application of gentle heat, the outline will be filled up, and the trees and flowers will assume their natural beauty and colors; on the heat being removed, the flowers, &c. will vanish, and the landscape resume its wintry appearance; these changes may be frequently repeated, should the heat applied not be too great.

LXII. *Gilding.*

The application of gold, as a covering, may be performed by a metallic mixture, as a pigment; by friction, as black-lead and colored chalks are used; by the chemical precipitation of gold from mercury, or some other solvent; or, lastly, by gluing, or fastening gold leaves to the surface intended to be gilt.

LXIII. *Gilding of Brass or Copper.*

Fine instruments of brass, that their surface may be kept longer clean, may be gilt by steeping them several times in a solution of muriate of gold, in which there is not an excess of acid, and afterward burnishing them.

LXIV. *An improved process for Gilding Steel.*

Pour into a solution of gold in nitro-muriatic acid, about twice as much sulphuric ether: the iron or steel must be highly polished: the ether which has taken up the gold is then to be applied with a small brush: it evaporates, and the gold remains on the surface of the metal; in this manner all kind of figures may be delineated on steel, by a pen or fine brush; lancets, razors, &c may be gilt in this way.

LXV. *Gilding Iron by means of Heat.*

Is performed by cleaning and polishing its surface, and then heat it till it has acquired a blue color; the first layer of gold-leaf is then put on, slightly burnished down, and exposed to a gentle fire; it is usual to give three such layers, or four at the most, each consisting of a single leaf, for common works, or two for extraordinary: the heating is repeated at each layer, and finally the work is burnished.

LXVI. *Water-Gilding.*

This term was probably at first confined to such processes as required a solution of gold in nitro-muriatic acid, and means a chemical application of gold to the surfaces of metals. A piece of polished steel will be gilt by being repeatedly steeped in a solution of gold copiously diluted with ardent spirits.

LXVII. *Gold Gilding by Friction.*

Dip a fine linen rag in saturated solution of muriate of gold, till it has entirely imbibed the fluid; the rag must then be dried over a fire, and burnt to tinder: the article to be gilt must be previously well burnished; a piece of cork is then to be put, first into a solution of salt in water, and afterward into the black powder of the tinder, and the piece, after being rubbed with it, must be burnished. This powder is frequently used for gilding delicate articles of silver.

LXVIII. *Shell-Gold or Gold-Powder,*

For painting, may be obtained by uniting one part of gold with eight of mercury, and afterward evaporating the latter by heat, which leaves the gold as a powder: or the metal may be reduced to powder by mechanical trituration.

LXIX. *Grecian Gilding.*

Equal parts of muriate of ammonia and muriate of mercury are dissolved in nitric acid, and a solution of gold is made in this fluid: the solution is concentrated, and applied to the surface of silver, which becomes quite black; but on being exposed to a red heat, it assumes the appearance of gilding.

DIRECTIONS TO MAKE

COLORS FOR PAINTING ON VELVET.

BRIGHT RED.—Take one dram of carmine, and boil it two minutes, with four table-spoonfuls of water; then add half an ounce of spirits of hartshorn and two spoonfuls of water: and the same in proportion to any quantity.

PURPLE.—Take half a pound of Campeachy logwood chips, one ounce of alum boiled in a pint of water until it is reduced to half a pint, then mix with gum dragon.

FINE YELLOW.—Dissolve two drams of gamboge powder in one ounce of spirits of wine, or put into a bottle one dram of saffron with a gill of water

YELLOW *to mix with Blue, for making* GREEN.—Take one ounce of French berries bruised, half an ounce of alum boiled in six spoonfuls of water for five minutes, and mix with gum dragon.

ORANGE.—Hay saffron mixed and dissolved in boiled water.

BLUE.—Prussian blue cake, or pink saucer rubbed up with lemon juice.

BROWN.—Burnt umber in cake, rubbed up with lemon juice.

GREEN.—Prussian blue, rubbed up with the yellow of French berries, according to the tint you want.

GUM DRAGON.—To half an ounce of gum dragon, put one and a half pints of boiling water; let it stand four or five days, and shake it up frequently.

VERY BRIGHT RED.—Pink saucers diluted with lemon juice.

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